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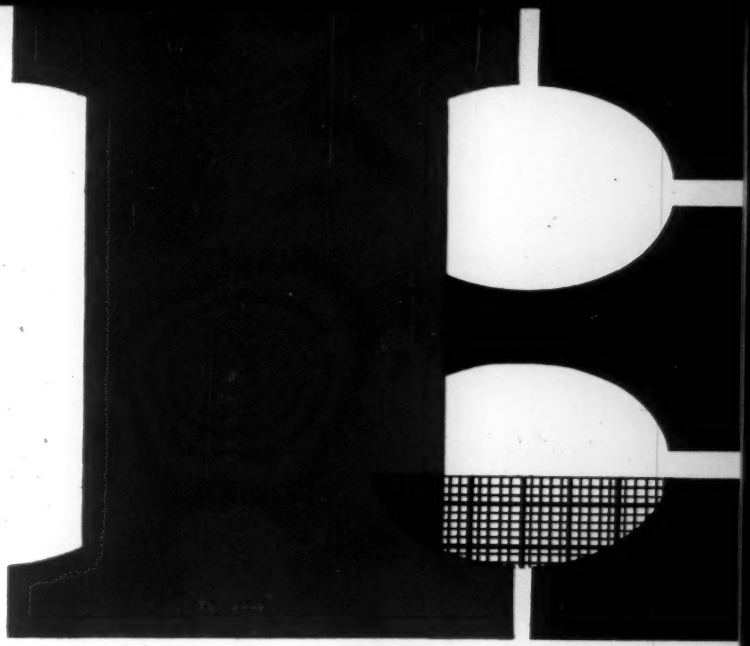

The Journal of **INDUSTRIAL ENGINEERING**

MARCH-APRIL 1961

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A Summary Report of t
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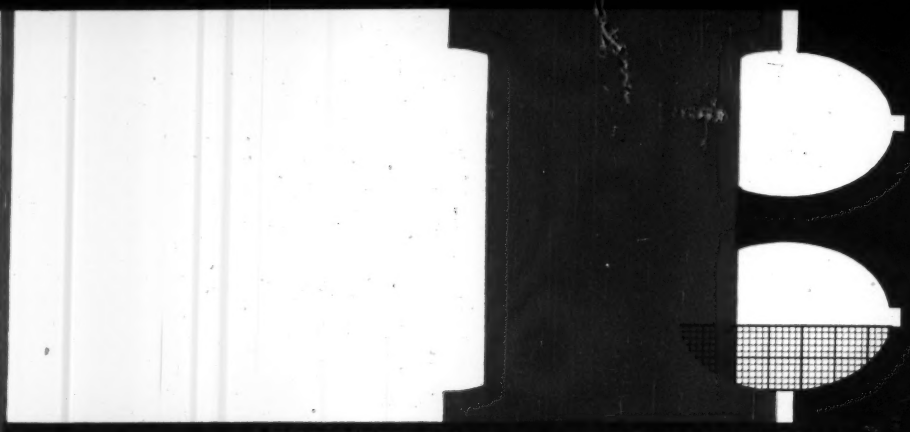

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The Emerging Role of Industrial Engineering

A Summary Report of Industrial Engineering Symposia Sponsored by the American Institute of Industrial Engineers

edited by **AUSTIN WESTON**

Secretary, AIIE Long Range Planning Committee

THE AIIE has grown tremendously since its founding in 1948. This growth has brought many new people into this Institute; it has also increased interest in the Industrial Engineer and his activities in business, government, service organizations and industry by those in management and related professions. As a result many questions have been raised concerning the Industrial Engineer, his duties and responsibilities, his relation to the engineering profession as a whole, his relation to management, and the tools and techniques he uses.

For several years the AIIE Long Range Planning Committee has been sponsoring symposia designed to find answers to such questions—to develop the "image" of the modern Industrial Engineer. The results of these symposia, while published individually over the years, have not heretofore been collected and merged into one account. This report is for the use of practicing Industrial Engineers, to give them a panorama of the changing nature and the widening scope of their profession, and for those in management and other areas who are interested in Industrial Engineering, to reveal to them the emerging role of the Industrial Engineer.

THE SYMPOSIA CONCEPT

The Industrial Engineering Symposia were conceived in early 1955 by two of the country's leading Industrial Engineers, D. G. Malcolm and C. W. Lake, Jr., as a result of discussions of problems facing this new and growing profession. They both felt that something needed to be done to solidify and improve the standards of the profession, and to clarify the functions of Industrial Engineering. This concern led them to invite a number of leaders in Industrial Engineering to a short meeting held during the AIIE National Convention in St. Louis in May of 1955.

At this meeting a number of opinions on the problems facing the Industrial Engineering profession were voiced and remedies for these problems were suggested. The following specific suggestions came out of this meeting:

1. The AIIE should develop a definition of Industrial Engineering consistent with the definition of Engineering.
2. This group should meet again for two days in the fall of that year at Cornell University to explore the subject further.

Thus the stage was set for the first of the symposia.

THE SYMPOSIA OUTPUT

Five Industrial Engineering Symposia have been held since 1955 (see Appendix No. 1 for dates and places). In general these symposia have served to define and explain Industrial Engineering, to illustrate the design process in Industrial Engineering, to emphasize the areas in which the profession can make its greatest contribution, and to explore the tools and techniques used in the Industrial Engineering process. They have developed the concept of the modern Industrial Engineer as the designer of productive and management systems and have outlined opportunities for the emerging role of Industrial Engineering. The participants in the symposia have been leaders in the industrial, academic, consulting and governmental branches of the profession (see Appendix No. 2 for the names).

The remainder of this report is concerned with a summary of the concepts developed in the symposia.

THE DEFINITION OF INDUSTRIAL ENGINEERING

Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of men, materials, and equipment. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict and evaluate the results to be obtained from such systems.

This definition was developed by the participants at the first symposium (3). It was intended to reflect the unique character of the Industrial Engineer, and it is sufficiently general to include the diverse areas in which Industrial Engineering can be of use. It was also intended to identify Industrial Engineering as an engineering discipline, and to place it within the scientific framework surrounding all branches of engineering. At the time of its development it was recognized that this definition could and should be improved as the need arose.

This definition was officially endorsed by the AIIE at its annual convention in May, 1956. Since this time it has been widely published and it is one of the best known definitions in the entire engineering field.

AN INTERPRETATION OF THE DEFINITION

The interpretation of this comprehensive definition to both lay and professional groups immediately created a

problem. Therefore, the next symposium was primarily concerned with communication and understanding of this definition (4). It was concluded that most of the other problems facing the profession, such as curricula design, organization and direction of research, proper publicity, and the attractiveness of the profession as a career, could not be properly approached unless the basic mission of the Industrial Engineer was communicated to and understood by all concerned. As a result, the members of the symposium decided that, while the definition need not be changed, it should be expanded and interpreted for specific groups. Four expository paragraphs were developed, each one aimed at explaining what an Industrial Engineer is and what he does. Each of the four paragraphs was written in terms which would mean most to one of the following groups:

1. Management.
2. Employees in Industry.
3. Engineers and Other Staff Groups.
4. General Public (with special emphasis for high school students).

These interpretations were recommended to the AIIE as aids in promoting better understanding of the Industrial Engineering profession. They are presented, not as the last word on this subject, but to provide a basis for future discussion and for use where appropriate.

1. INTERPRETATION FOR MANAGEMENT[1]

The Industrial Engineer makes an engineering contribution to achieving management's objective, primarily that of optimizing the gains and minimizing the risks of an enterprise. He assists every level of management by originating and developing operating plans, programs and controls which will permit the increasingly effective use of human and economic resources.

This is accomplished through stimulating and working with other staff and line departments in such fields as:

—making location and site, layout and handling plans.
—designing organization and operating procedures.
—designing controls for organization functions.
—designing tools and equipment, work processes and methods.
—designing compensation plans.
—determining the most economic way of procurement and use of materials.
—analysis and evaluation of data and other information required for these planning tasks.
—conducting research in these areas.

2. INTERPRETATION FOR EMPLOYEES IN INDUSTRY

The Industrial Engineer is a fellow employee who is concerned with the problem of finding easier ways for you to do your work. He is not your boss, but is merely an advisor to you and your foreman. Obviously he is not as skilled in doing your particular job as you are, but he does have certain special training and experience, especially in the analysis of work. With your knowledge of the job, and his knowledge of ways to analyze and study work situations, he can help you work out an easier way to get your job done. As easier ways to do your job are found, costs will be reduced, and your company will be able to sell your products at a lower price. This will create a greater demand for your products and more jobs.

Not only is the Industrial Engineer interested in improving what you yourself do, but he must be concerned with those things which affect your production, and over which you have no control. The equipment you use, its position in the plant, the building in which you work, the way in which your work is scheduled, and the condition of the work you receive are examples of these factors.

In his role as an advisor to you, your foreman, and other management people, he is continuously looking for further improvements, and therefore is never satisfied with things as they are. He attempts to keep up with the best practices and newest devices in order to make sure your company is always doing every job in the best possible way.

3. INTERPRETATION FOR ENGINEERS AND OTHER STAFF GROUPS

The Industrial Engineering approach is a unique application of engineering design and analysis techniques. The Industrial Engineer's consideration of people, the design of systems involving people, and the manner by which human performance is analyzed requires a fundamental, analytical approach that is essentially different from other engineering disciplines.

The contribution of the Industrial Engineer is in the management decision-making process. The problems existing in this area deal with the optimum utilization of men, materials, equipment, and energy to achieve the purpose of an organization. The organization may be an individual department of a company, a hospital, an entire corporation, or any other group organized to produce a product, perform a service or carry out a function. The managers of the organization need factual information arranged to define alternatives and consequences, to help them recognize and solve existing problems. The Industrial Engineer collects, analyzes, and arranges this information in such a way as to fulfill this management need, as well as searching for better ways to do the job. The Industrial Engineer operates in two major areas, the design of new systems and the maintenance and improvement of existing systems.

To summarize, in his work the Industrial Engineer:

1. Identifies problems, gathers facts and appraises difficulties.
2. Visualizes solutions and designs, develops or improves systems.
3. Searches out requirements for quality, quantity, cost and timing.

[1] "Management" is defined to mean anyone with line responsibility and authority to direct others in any type of activity; everyone from President, General Manager, and Superintendent to Foreman.

4. Makes economic analyses and justifies their results.
5. Specifies, constructs, installs and, sometimes, initially operates these systems.
6. Devises methods of controlling and evaluating the performance of systems.
7. Develops acceptance by and secures cooperation of those who operate such systems.

The Industrial Engineer is distinguished from other engineers in that he:

1. Places increased emphasis on the integration of the human being into the system.
2. Concerns himself with the total problem.
3. Predicts and interprets the economic results.
4. Makes greater utilization of the contributions of the social sciences than do other engineers.

4. INTERPRETATION FOR THE GENERAL PUBLIC (WITH SPECIAL EMPHASIS FOR HIGH SCHOOL STUDENTS)

The Industrial Engineer is concerned with the design of industrial enterprises or other types of organizations existing for a worthwhile purpose, and the planning or blueprinting of the combination of men, equipment and materials necessary to produce most effectively desired goods or services. The Industrial Engineer differs from other engineers in the degree that his fundamental concern is with operations that result from both physical and human forces, and are measured in both physical and economic terms. Therefore, he is educated not only in the engineering methods of analysis and design which stem from mathematics and the physical sciences, but also is concerned with psychology, physiology, sociology, economics, costs, and human relations.

He may be dealing in the automation of the manufacturing process, in the development of methods of handling materials, in the development of procedures to control production, or to measure performance of any type of work. He frequently serves as management's advisor in the solution of special problems.

In doing his job he comes in contact with all functions of an organization and employees at all levels. He must be able to deal, not only with the technical aspects of his problems, but also the human. Philosophically, he is devoted to the ideal of helping the nation to use most effectively its physical facilities and human talents for production of goods and services.

A person considering Industrial Engineering as a career will find it one of the most rewarding in terms of challenge, recognition, and satisfaction. The Industrial Engineer starting on his career receives the excellent financial compensation of other engineers. The modern Industrial Engineer not only utilizes the traditional engineering tools and techniques in performing his role, but also makes effective application of such new developments as electronic computers and modern data processing devices. In addition, the many new developments in management science are best applied by individuals with the type of education and experience possessed by competent Industrial Engineers. Many Industrial Engineers, by virtue of their area of endeavor and the breadth of their experience, have and will continue to progress into top management.

SYSTEMS DESIGN

One of the key phrases in the Industrial Engineering definition is "systems design". This phrase both indicates the relationship of Industrial Engineering to engineering and emphasizes the unique feature of Industrial Engineering. A symposium was devoted to the presentation and analysis of typical case histories to illustrate the design process in Industrial Engineering, the growing attention to systems problems, the relationship of Industrial Engineering to other branches of engineering, the way in which Industrial Engineering must be co-ordinated with other staff activities, and its operation as an internal consulting function (1).

CASE I

Warren Alberts, Director of Industrial Engineering[2] United Air Lines, presented a case on the Analysis and Design of an Airline Reservation System.

The operation of an airline, both from a profit and passenger service standpoint, is extremely dependent upon the speed and accuracy with which it handles and controls the space it has for sale.

United Air Lines' management, in 1955, decided on an over-all analysis of the company's reservation function, including the possible design of a system which would take care of its projected needs through 1965. The system at that time employed over 2,000 people, cost approximately $12,000,000 a year to operate, and was handling up to 50,000 transactions a day. This system could be visualized as a large information processing complex covering some 80 stations spread throughout the country.

The Industrial Engineering Department of United Air Lines undertook the direction of this study. A study team was given the assignment to:

1. Analyze the entire system.
2. Isolate the basic problems.
3. Measure the key variables and project the system and its requirements 10 years into the future.

To help the team concentrate on developing requirements, their initial goal was set as the development of a functional specification. This first phase took approximately a year to complete. Basic problems such as time lags, exposure to human error, divided responsibility, and the inability of people within the system to audit their work, were highlighted. Problems susceptible to short range solutions were turned over to operating groups and an interim system, utilizing IBM Ramac computers at Denver connected to transceivers in the largest reservations offices, was installed.

[2] Subsequently Vice President, Industrial Engineering, now Vice President, Assistant to the President, United Air Lines.

The functional specifications which contained volumes and desired service levels in very specific terms soon pointed up the limitations of existing electronic hardware and communications networks.

A second phase, that of system design and translation of the functional specification into a technical one, was undertaken. Stanford Research Institute was called in as a consultant to evaluate existing technology and help specify a realistic system. Concurrent with the development of technical specifications, a complete economic analysis of existing manpower and machine costs, along with the value of meeting specific design requirements, was made.

This system study, which spanned a period of two years, finally resulted in the procurement by United of a highly advanced electronic reservations system which will not only meet its specifications, but also make an important contribution to profit and increased productivity. The study also pointed up the need to consolidate certain functions basic to the system which previously had been spread out among several departments. These organizational changes were made.

The project dramatically highlighted the importance of taking an over-all Industrial Engineering approach to the analysis and design of complex systems which involve both technical and human aspects. An important point in the approach taken is the development of system requirements which manufacturers are asked to meet as opposed to the current practice of trying to adopt and integrate existing hardware to meet business needs. The results, both in satisfying the company's requirements and in improveing productivity, point up the value of allocating Industrial Engineering effort to the research and development of business systems.

CASE II

Richard Forberg, Director, Industrial Engineering Division, Procter and Gamble Company, presented a case study of the Design of a Synthetic Detergent Production and Distribution System.

A system to produce and distribute synthetic detergents was presented as a whole. The major information flows and the product flow were indicated graphically.

The system was divided into sub-systems, each of which was a major project area. The work on the sub-system for production scheduling and inventory control was presented as a typical project. This study team developed a production scheduling procedure which considered all the significant costs and reduced the time lags in decision making. Installation of the improved system involved simulation, parallel runs, and limited scale tests.

Another sub-system discussed briefly was the mechanized material handling of packaged, finished product. Equipment components for such systems have become commercially available. Designing an integrated system to perform over a wide range of expected levels of consumer demand and modifications of product mix required a total system approach. The use of the Monte Carlo method of simulation to test alternative designs was outlined.

A third sub-system involved the processing of customer orders on electronic data processing equipment. Orders were taken on mark-sense cards by salesmen. A system to process all subsequent paper work necessary for shipment, accounts receivable, sales analysis, and product inventories was under design.

The key role of the Industrial Engineering Division in system design on these separate projects and for coordination at the corporate level was emphasized.

CASE III

George Gustat, Director, Industrial Engineering Division, Eastman Kodak Company, presented a case study of the Mechanization of a Finishing Operation.

An industry was pictured that had successfully employed Industrial Engineering for many years. It has used ideas such as measured work, cost control, quality control and scheduling to strongly aid the organization. In an economic climate of rising input costs, Industrial Engineering had contributed to holding the costs to such a level that it was unnecessary to raise sales prices. However, an expanding market demanded an accelerated growth in production. This, coupled with technological complexity, required that planning be shifted from a five year basis to projections of ten and fifteen years. The conventional methods of Industrial Engineering then being employed were no longer adequate.

A team was used to assess the situation aggressively. A large number of new ideas were presented and scheduled to be worked out and installed in the next ten years on a scheduled priority basis. These suggestions ranged from very minor ones to complete revisions of the productive system.

One of these ideas was presented to demonstrate the development of this improvement scheme. In this case, large quantities of product were being inspected in a rigorous manner to get a product with a low defect rate. To attack this potential problem more effectively, it became necesary for the Industrial Engineer to form a part of a specialized team. It was emphasized that an Industrial Engineer concerned only with restricted techniques would have had little success with this problem, requiring as it does technical knowledge from other fields. Since the present operation was profitable, there was a considerable tendency to multiply the existing types of facility to meet the new demands. A complex machine was developed to replace the human inspection and handling previously employed. The evolutionary development, testing, installation, and redesign were continued over an extended period with a follow-up of Industrial Engineering techniques applicable to a man-machine work unit of high value. Now, the new machine produced a systems schedul-

ing problem for the Industrial Engineers that required a more sophisticated solution.

The success of this productive equipment influenced the expansion plans. Here it was noted that each progressive and needed change in the system caused more changes involving more coordination and planning in the over-all system. In summary, the over-all economic influences and pressures caused Industrial Engineering to become oriented toward an expansive, dynamic improvement program. The narrow and admittedly static concepts of thinking previously used were now being directed toward a broader and more progressive view of the system and the larger potentials for use of resources.

CASE IV

L. T. Ohmart,[3] Manager, Industrial Engineering Department, Armstrong Cork Company, presented a case study of Organization for Systems Design.

The modern national trend in Industrial Engineering has continued to emphasize systems engineering. This has resulted from the realization that Industrial Engineering problems cannot be completely divorced and isolated from their environment. For the Industrial Engineer to properly function, it is necessary that he become less specialized and have a good command of the broader Industrial Engineering functions.

To better serve the needs of making and marketing a competitive product an interesting organizational change was reported. Specialization was deemphasized and individuals with broad scope and background were assigned to areas of functional responsibility. These individuals were grouped into a developmental team that had successive responsibilities as a new product was developed and marketed.

A case study was presented showing the accelerated and coordinated stages employed as a floor backing was successfully moved from research to production. The group of broadly oriented personnel composed a small, coordinated team that now employed various specialists as internal consultants. As the product progressively developed on a time scale, each responsible member of the team could draw on specialists to assist him in accomplishing his part of the mission. The team members were generally drawn from production, research, project engineering and Industrial Engineering.

Successful experience in this organization has shown that if systems engineering work is to be effective, responsible staff people must know and respect what effects their actions will have on other parts of the organization. If the Industrial Engineer is to participate in this system, he should develop a perspective that enables him to look at any problem as an integral part of the whole system.

This orientation of thinking had also been demonstrated to be excellent training for handling emergency systems problems.

From these case studies, what conclusions can be drawn concerning some of the major and distinguishing general aspects of Industrial Engineering?

1. The concept of opportunity-oriented solutions to problems.
2. The concept of Industrial Engineering as a continuum for all management levels.
3. The concept of the emerging role of the Industrial Engineer in a dynamic profession of engineering.
4. The concept of Industrial Engineering as a research, developmental and creative staff function.
5. The recognition of the similarities of the Industrial Engineering systems concepts with those of other branches of engineering. A recognition of some of the distinguishing differences, such as the emphasis on the human component, economic orientation, degree of predictability and probabilistic nature of problems.
6. A recognition of the inadequacies of information about communication from the viewpoints of man-to-man, man-to-machine, or machine-to-machine transfers. Systems design is of course critically dependent upon knowledge of this type.
7. A recognition that both the practicing and academic Industrial Engineer is broadening his intellectual scope as he views and practices Industrial Engineering.

TOOLS AND TECHNIQUES FOR SYSTEMS DESIGN, AND THEIR USE

What are the major tools and techniques that the Industrial Engineer uses in designing systems? The symposium group that examined this subject felt that the list was quite extensive (5). This group did not examine the degree of knowledge and skill the Industrial Engineer should have in each of these areas. The levels of knowledge extend from expert or comprehensive to elementary, i.e. enough to recognize a need and to know where to find expert advice. However, there was agreement that the Industrial Engineer serves as the unifying force in bringing together the knowledge and talents of the various scientific and engineering disciplines, and in developing means for integrating them into a cohesive team to assist management.

Since the Industrial Engineer is concerned with the design, improvement and installation of systems involving men, materials, and equipment, he must have fundamental training in mathematics, physics, chemistry, and in the engineering sciences. The treatment of the human component of the system requires knowledge of the behavior, motivation, capabilities, and limitations of people. Knowledge derived from training in the social sciences, as psychology and sociology, is necessary to predict and describe the variations in the performance of men, equipment and processes and the environmental factors affecting them. The Industrial Engineer makes extensive use of probability and mathematical statistics. A wide variety of special tools and techniques are used in the analysis and design of complex integrated systems. Among these are methods of linear and dynamic programming, gaming theory, digital and analog simulation techniques, control theory, computer applications, and many others asso-

[3] Now Consultant, Methods and Time Standards, General Electric Company.

ciated with recent developments, as well as such tools as process charts, methods analysis and others long associated with Industrial Engineering activities.

The evaluation of both systems and components requires familiarity with various branches of economics and with the techniques of modern decision theory. Tools used in setting standards for and in measuring the performance of men, equipment, and systems range from work sampling, micromotion and time study to synthetic time standards. Since he works closely with management, the Industrial Engineer must be familiar with management principles and organization theory. He must have the experience, skills, and knowledge necessary to design, analyze, and evaluate systems used by management for control of cost, production, and quality. Because he deals with people at every level of the organization and because his work directly affects the activities of these people, the Industrial Engineer must have the special skills necessary to convey his ideas and results by verbal, written and visual methods. This problem of efficient communication is becoming more important as our requirement for more frequent change increases.

How does an Industrial Engineer use these tools and techniques when he first contacts the reality of the problem area? In the initial or *survey phase* he utilizes visual observation and preliminary data samples to design subsequent approaches and determine the scope of his analysis. He would include a review of records that are available for an existing activity and a check for similarities to existing activities if the design is new. From these he would begin to develop a conceptual model of the area under investigation and to comprehend directions in which improvements may be made. The whole process of design through which the Industrial Engineer may subsequently go is carried out in a rough conceptual way in this first approach.

Next the Industrial Engineer must usually design a method of *obtaining additional information.* Normally, this will require the selection of suitable units of measure and the design of data collection or the use of experimental statistics to design such procedures.

The third phase is *modeling,* putting measurement into a form representing some important aspects of the situation. Many tools and techniques are useful in this phase: job standards, process charts, flow diagrams, layout models, simulation programs, or a wide variety of mathematical formulations.

What techniques are available for *manipulating the model* that has been constructed? The simplest manipulative activities are those which the Industrial Engineer recognizes in the "why" approach of work simplification, as used with a job description, process flow chart, or plant layout. For other models, appropriate manipulations are chosen: for example, Monte Carlo methods in process simulation. In addition to the manipulative techniques, the Industrial Engineer uses his creative imagination and experience to develop a range of alternative solutions to the problem.

These phases are part of a repetitious, cyclical process which may be repeated several times to evolve a design which meets the final design criteria, and which may also be analyzed by the critical processes or decisions of management.

THE INDUSTRIAL ENGINEERING PROCESS

The combination of activities referred to immediately above can be considered a part of the Industrial Engineering "process"(2). This process can be charted to facilitate its understanding and discussion (Figure 1). The chart is intended to graphically illustrate these activities and to classify them as either operating, engineering, or research. The boxes across the top represent the engineering activities in the Industrial Engineering process. Across the bottom are the "operating" activities which have often characterized the Industrial Engineering Department in a company. As has been noted, the trend is away from such narrow use of the term "Industrial Engineering" by management. Up the left side is illustrated the research activities, the refinement of existing techniques, the development of new techniques and problem solving tools, and the transfer of techniques from other areas of endeavor. The relation to management and the objectives of the organization are also noted. The symposium group endorsed the diagram as depicting the process by which change can be engineered and controlled—i.e., the *Industrial Engineering Process.*

AREAS OF OPPORTUNITY FOR THE FUTURE

The Industrial Engineering concept has been defined and explained. The unique aspect of this branch of engineering, systems design, has been defined and illustrated by case examples. The tools and techniques of the Industrial Engineer and the manner of their use by him have been examined. A key topic remains to be explored: areas of opportunity for the continued application and future growth of the Industrial Engineering approach.

The symposium group that discussed this subject felt it important to set the stage for this discussion by depicting how modern management thinks of an Industrial Engineer (6). In addition to his traditional role in work measurement, cost studies, plant layout, etc., management now looks upon the Industrial Engineer as one concerned with:

1. Analyzing, developing, and implementing an entirely new system consistent with modern decision methods and computer technology.
2. Improving the performance and output of an existing system of men, machines, materials, and information regardless of whether it is in the manufacturing function (where most Industrial Engineering activities have sprung up and are concentrated) or in the budgetary, legal or sales function.
3. Improving the design of existing controlling systems.

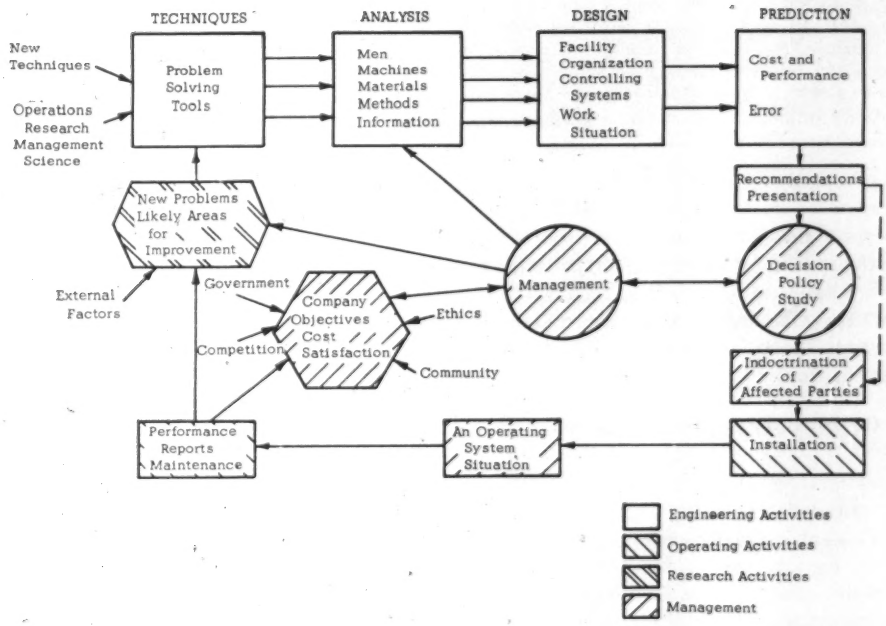

FIGURE 1. The Industrial Engineering Process.

Further, three trends in the pattern of the Industrial Engineer's activities were noted. The first trend is a shift in emphasis from action after the fact to action before the fact on the part of the Industrial Engineer, i.e. a shift from controlling or helping to control what exists to the task of *designing* improvements or innovations. Thus, in addition to the opportunity to develop solutions for a given problem, management is giving the Industrial Engineer opportunity to diagnose the basic problem and to search out new solutions.

The second trend observed is the use of the Industrial Engineer in a more creative role in support of dynamic modern business. In implementing the concepts of science and engineering, management is faced with many problems of an application and acceptance nature. The Industrial Engineer is turning from the routine operation of various controlling systems to the task of speeding the installation of new manufacturing technologies and the timely acceptance of change by those affected. Support of such research and development activities by Industrial Engineering analysis is producing much needed reduction in installation time for new products and processes, as well as new systems of management.

The third trend lies in the increasing development of factual and unbiased solutions based on an increased ability to measure, understand, and manipulate systems. The Industrial Engineer has a significant role in the use of operations research and system analysis for such studies. In addition to such study, the Industrial Engineer is concerned with more than merely being responsible for the development of such solutions. He also lays the foundation for ultimate acceptance at the very outset of his work; he should keep up the promotion and stimulation of interest during his work; and he should complete his work with a presentation which utilizes the skills necessary to secure the full understanding needed for a decision to accept and implement.

The major areas where the Industrial Engineer can directly serve management in key staff-role were identified:

1. Establishment, clarification, and modification of company objectives. The definition of mission and direction of a company as well as its components.

2. Design of an organization or a system of human physical resources used to accomplish these objectives.

3. Recommendations concerning the allocation of the resources that have been organized, whether they be staff, operating, or line. This allocation must not only be initially determined but must be kept continually in balance. Here management is looking for an engineering approach in the determination of where their dollars, their human, or their physical resources can be invested for the greatest return.

4. Design of the basic system by which these resources are utilized. Included here is not only the operational system by which these resources distribute or provide goods and services, but also the staff system which serves the operational system. The same types of operational improvement are possible in functional areas outside of the traditional manufacturing area—for example, sales and research and development control.

5. Design of control systems for these resources. The systems by which the planning, scheduling, or co-ordinating of resources is done represents an important area for company improvement and is a challenging design opportunity.

6. The evaluation of results achieved in the performance toward objectives, i.e., the realization from the investment in human, physical, or money resources as measured by the satisfaction of human and management wants. Such evaluation, though difficult,

provides conclusions which when fed back close the loop described in sections 1 through 5. If the realization obtained is not satisfactory, the Industrial Engineer is asked to re-examine the organization, objectives, allocations, resources, use, control and realization. This full circuit can be generally applied to any type of organized human activity—industry or government, product or service producing.

In these areas management is looking to an Industrial Engineer more and more as an individual who can step back far enough from the day-to-day operations to observe objectively the system by which the company is run rather than as a specialist in a particular area. Further, management looks to an Industrial Engineer to assist in interpreting what he has seen and experienced to the other people in the organization.

THE RELATION OF INDUSTRIAL ENGINEERING AND MANAGEMENT

Much of the material developed in the symposia has centered on the contributions of Industrial Engineering to management. This subject was discussed at the Northwestern Symposium by Dr. Alex Rathe (AIIE National President for 1960-61), where it was pointed out that Industrial Engineering employs engineering thinking, principles and methodology. It also uses the knowledge from other fields, particularly the physical and social sciences and mathematics. The mission of the engineer is "design," that of management is direction of "operations."

Where the Industrial Engineer serves management, he can perform many managerial tasks. However, these can only be in the service and auxiliary phases of management—i.e. in planning, in review, and in management research and development. In the "operations" section of management the engineer, as an engineer, is a stranger. Some engineers have become effective managers in management's main area, that of operations. Before this could occur, these persons had to develop special personal traits and gain experience and knowledge beyond that acquired in engineering. The reverse movement (where managers have become engineers) has only rarely occurred in the past and is less likely to do so in the future.

A dramatic change has taken place in the Industrial Engineering profession. Emphasis is now being placed on action before the fact rather than after. Greater attention is now being given to the creative role in support of dynamic modern business. And most importantly, the Industrial Engineer is now teaming with others to stress the scientific, the economic and the management aspects of an organization.

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(3) Weston, Austin, "Summary of the Industrial Engineering Symposium, Cornell University, October 1955," *Journal of Industrial Engineering,* May-June, 1956, pp. 98-100.

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(6) Weston, Austin, "Summary of the Industrial Engineering Symposium, Northwestern University, November 1959," *Journal of Industrial Engineering,* March-April, 1961.

APPENDIX NO. 1

SYMPOSIA DATES AND LOCATIONS

1. Cornell University, Ithaca, New York, October 20 and 21, 1955
   Host: Dr. Andrew Schultz, Jr.
2. Purdue University, E. Lafayette, Indiana, November 15 and 16, 1956
   Host: Professor Harold Amrine
3. Georgia Institute of Technology, Atlanta, Georgia, November 7 and 8, 1957
   Co-Hosts: Professor Frank Groseclose, Dr. Robert Lehrer
4. University of Iowa, Iowa City, Iowa, November 10 and 11, 1958
   Host: Professor Wayne Deegan
5. Northwestern University, Evanston, Illinois, November 16 and 17, 1959
   Host: Dr. Robert Lehrer

APPENDIX NO. 2

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Industrial Engineering

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